KEYWORDS: ***Petroglyph – Bronze Age – Sandal – Mesolithic – Kamyana Mohyla – Ukraine***

A COMPLEX ROCK ART OBJECT IN THE UKRAINIAN STEPPE

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Abstract. The unique rock art site of Kamyana Mohyla in south-eastern Ukraine contains numerous petroglyphs from different chronological periods. 3D-modelling and mesh-analysis of rock art were applied to Ukrainian rock art occurrences for the first time. They have permitted a revision of the interpretation of a particular decorated panel at this site. Previously considered to represent a mythological dragon originating from Indo-European texts, this palimpsest has a multilayered structure that was created and modified during millennia by rock artists from different cultural groups.

Introduction

Despite many mysteries and questions, rock art of pre-Historic Europe has been widely studied, described and is available to any European archaeologist. This availability seems significantly lower when it comes to Ukrainian rock art, especially in the Ukrainian steppe. Few sites are known, and even fewer are published. Barely any one of them is studied and presented to the scientific community in its completeness. The complex of Kamyana Mohyla (Fig. 1) is one of those that did receive some attention. Kamyana Mohyla monadnock (inselberg or monolith) consists of a few 14-million-years-old blocks of sandstone that formed in deposits of the Sarmatian Sea. Rising above a river valley, it has always drawn the attention of ancient populations of the region. Numerous petroglyphs were made within the site along with slab fragmentation that created caves and grottoes. Nowadays, natural factors continue

Figure 1. *Aerial view of Kamyana Mohyla (by DN).*

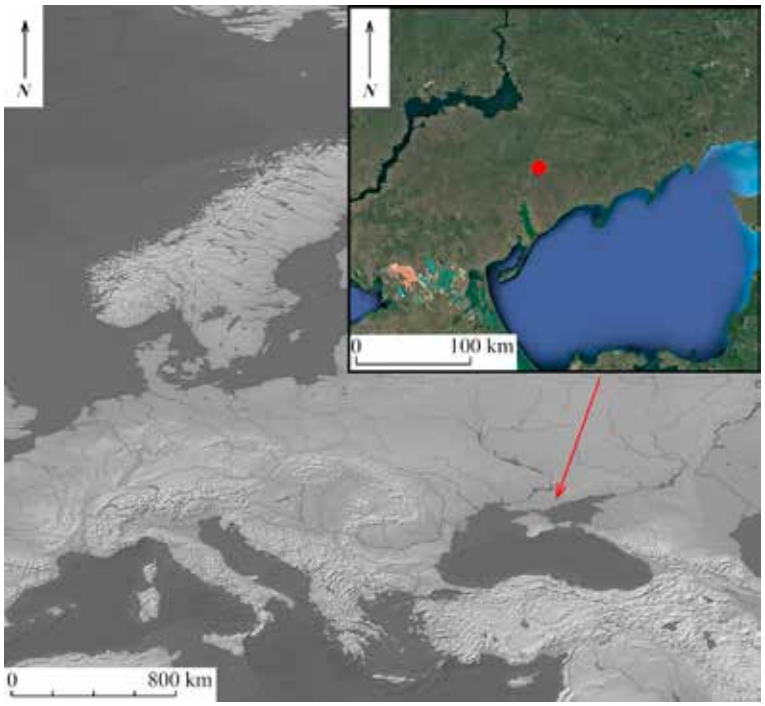

Figure 2. *The location map of Kamyana Mohyla (by SR).*

intensively to destroy the monadnock. As of today, 67 rock art locations (Mykhailov 2017: 13), purportedly dating from final Palaeolithic to the Modern Age, were found. In order to preserve, study and popularise the complex a historical and archaeological reserve was created, and the study of the petroglyphs began more than a century ago (Mykhailov 2005: 31–41). The relatively low popularity of the site is connected with the lack of publications beyond former Soviet countries — only one paper is known (Gladilin 1969). Notably, the site's petroglyphs vividly demonstrate the life of Ukrainian steppe dwellers — Mesolithic hunters-gatherers as well as the first representatives of steppe Neolithic of Ukraine and one of the first Indo-Europeans in Europe.

A new stage in the study of the northern Azov Sea region site (Fig. 2) is connected with the investigation of a nearby multilayer settlement (Kotova et al. 2017). Lower levels of the settlement contained portable palaeoart instances that appeared to be Mesolithic (Kotova et al. 2018). A brief inspection of how well Kamyana Mohyla is studied and preserved raised the possibility of using modern technical and methodical tools, popularisation abroad and revitalisation of the complex. The study started with 3D modelling and publishing petroglyphs from the Bull Grotto and continued by creating and testing fundamental approaches and methods (Radchenko and Nykonenko 2019). Under current geographical, climatic and economic conditions, the main objectives are to digitise, study and preserve as many petroglyphs of this unique European complex as possible.

Some of the most informative and interesting petroglyphs of the site are in so-called Dragon Grotto (Mykhailov 1992) (location No. 55, Fig. 3.1), discovered by B. Mykhailov in 1985 on the northern slope of the hill (Mykhailov 1987). The palimpsest is under a large block, between the so-called 'northern' and 'north-western' grottoes. The most interesting object of the site is a voluminous sandstone ellipsoidal protrusion (length 0.57 m, centre width 0.35 m, bottom width 0.54 m) (Fig. 3.2). Its left side is full of zigzags, lines of parallel notches, crossing lines and cupules left by tools made of hard material (Fig. 4). The right side is unmarked, most likely because it is hard to reach in the limited space between sandstone slabs.

Many times the object has attracted the attention of researchers (Mykhailov 1987, 1992, 1993, 2005), who made different assumptions on age and interpretation. B. Mykhailov was the first to draw the figure that takes up almost all of the cavity's space (1992: Fig. 1–2, 3.2) (Fig. 5). He connects the sculpture with the cult of a chthonic creature, vishap, which lives inside a cave in a sacred mountain (Mykhailov 2005: 126). Vishap is the name of a mythological fire-breathing snake that lives in Armenia, at the sacred Mount Ararat (Vahanyan and Vahanyan 2011: 452). This name was later extrapolated to 'dragon stones':

Figure 3. *Blocks that cover the location No. 55 (1) and placement of the figure inside the narrow grotto (2) (by SR).*

cigar-shaped huge stones, 10–20 feet tall, usually situated near the sources of rivers and lakes. Many of them are in the shape of fish; they have bull's skin … carved into them; there is also a stream of water flowing from the mouth of the bull's skin and some vishaps have images of water birds carved below the bull's head (Petrosyan 2009: 1).

Figure 4. *Images of the palimpsest of petroglyphs: front (1), left side (2) (by AV).*

Unfortunately, our predecessors could not make accurate images of the site because of the narrow space that makes a proper photographic recording impossible. Moreover, the grotto contained much sand that could not be removed since it could provoke a collapse.

Research method

The described complex of petroglyphs and sculpture was unavailable up until 2018 when heavy rain washed out the sand. It became possible to create a photogrammetric 3D model of the figure (Fig. 6), study and draw its petroglyphs and trace their stratigraphy. Aside from modelling and mesh analysis, the obtained model made it possible to visualise the figure and study it from any angle and individually, in orthographic projection (reduced version of the model available at *https://sketchfab.com/3d-models/vishap-from-kamyana-mohyla-bb763a9a972347e491c0ff2c0ec0f77c*) (Fig. 7). The figure cannot be shown on an isometric plan without deviations due to its irregular shape. Consequently, the new drawing of the petroglyphs (Fig. 8) was made using a combination of a few ortho-images. It has not the highest measuring accuracy but is far more detailed and accurate than the image of B. Mykhailov (Fig. 5).

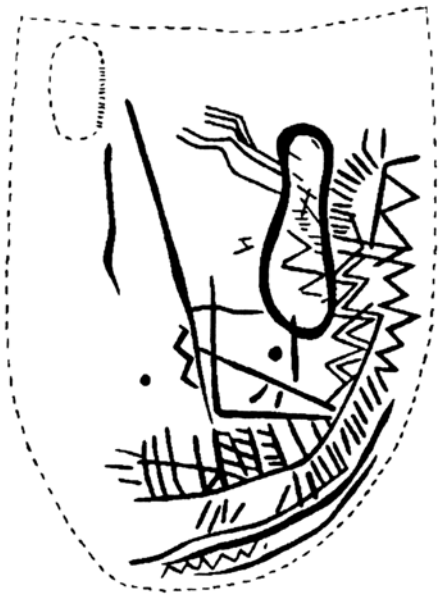

Figure 5. *Drawing of the Kamyana Mohyla location No. 55 by B. Mykhailov (after Mykhailov 2005: 240, Fig. 66.2).*

Since Kamyana Mohyla petroglyphs are on soft sandstone, researchers complain about methodical difficulties they face during their interpretation (Danilenko 1986: 51; Kotova et al. 2018; Radchenko and Nykonenko 2019: 49–50). The problems of direct dating of petroglyphs (most of them, but not all) through U/Th analysis or the like are the first to be mentioned. If we are to classify rock art research methods by Paul S. C. Taçon and Christopher Chippindale (1998), we also have to acknowledge the ambiguity of informed methods due to lack of space for such analogies or reliable connections with specific ethnohistorical sources. The discoverer of the figure tried to interpret it (Mykhailov 1993; Mykhailov 2005: 126–129), although his interpretation and dating should be reviewed in the light of new data.

For re-interpretation, it is reasonable

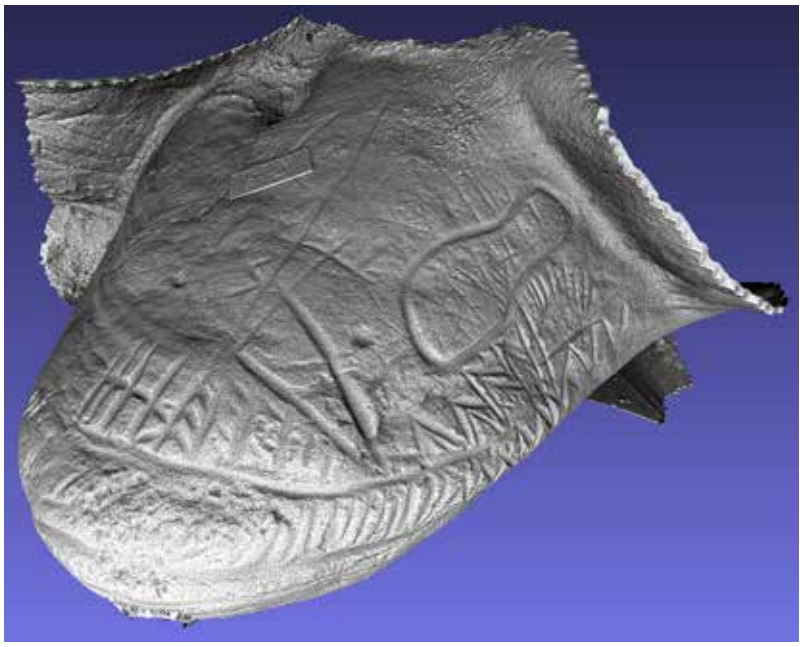

Figure 6. *Mesh of 3D-model (by SR).*

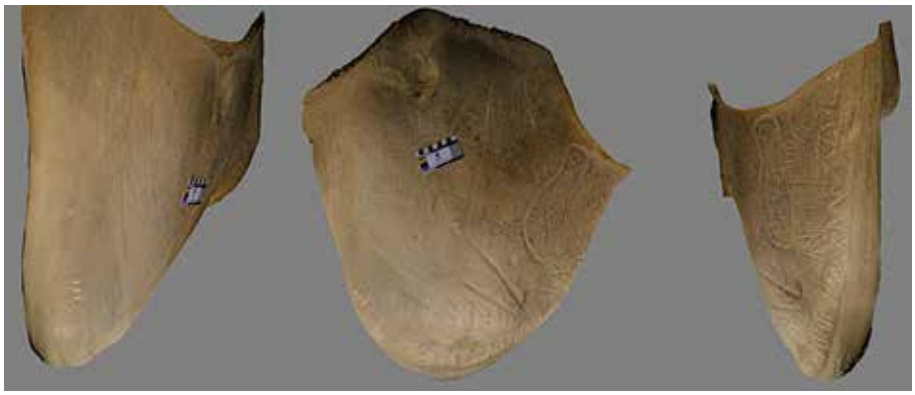

Figure 7. Orthographic image of the vishap, from different viewpoints (by SR).

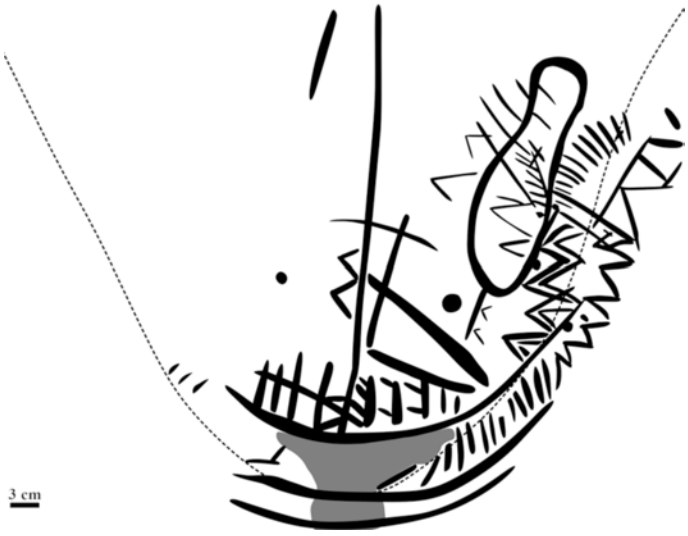

Figure 8. Drawing of the vishap figure, made after orthophoto-images (by SR).

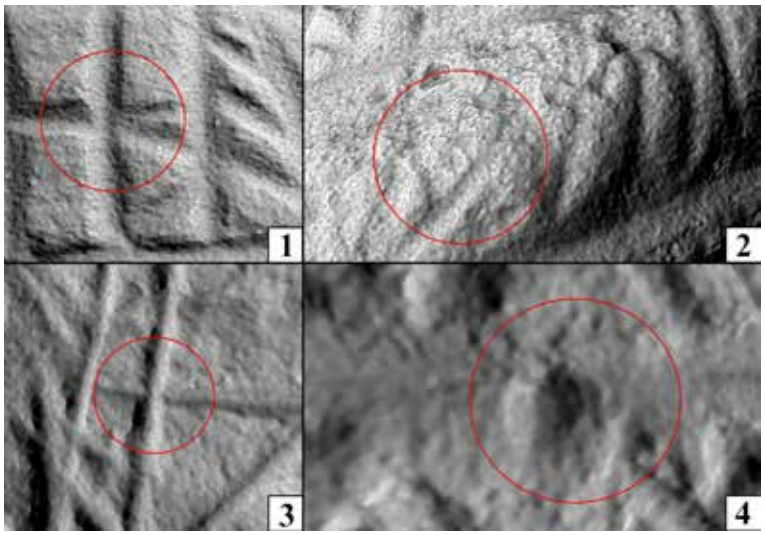

Figure 9. Superimpositions that provided data on the petroglyphs' relative chronology. (1) horizontal lines superimposed by vertical ones in zone 3; (2) vertical lines inclination after the partial destruction of the zone 5; (3) horizontal line superimposed by vertical one in the zone 4; (4) cupule engraved on the border of the horizontal line (zone 5) (by SR).

to collect all available data from the figure and its model beforehand. Studying the stratigraphy of petroglyphs and restoring the sequence and, consequently, a relative chronology of their creation is one of the validated methods (following Chippindale et al. 2000). Structure-for-motion photogrammetry with succeeding mesh analysis seems perfectly suitable for this study. The analysis was made using MeshLab tools. A total of 186 images were aligned in Agisoft Metashape to create 7-million-polygon surfaces of the photogrammetric model of the figure. Mean square deviation of the length measurements on the model is less than 2 mm, coordinate markers reference error 0.36 mm.

The methods and means of petroglyph analysis using 3D modelling techniques were developed and implemented in the past 20 years. Using particular algorithm filters and software, it is possible to define the superimpositions of scratches and engravings on rock art instances (see Mélard 2010; Mélard et al. 2016; Arcá 2018). Detailed and accurate analysis is usually done using laser scanning techniques (Hermon et al. 2018); however, photogrammetry also can contribute to this method. It has been already proven by previous research on Kamyana Mohyla (Radchenko and Nykonenko 2019). To improve the quality of interpretation, several 3D visualisation tools (e.g. radiance scaling and ambience occlusion in MeshLab) were used. According to Porter et al. (2016), these tools, together with light simulation, can replace RTI-techniques (also see Graff et al. 2018 on that topic). The obvious benefit of that is the possibility to simulate the light conditions in 3D space, whereas using RTI usually implies 2D imaging. Applying all these tools to Kamyana Mohyla petroglyphs has pointed out a few crucial details that define the petroglyphs' superimposition (Fig. 9).

In order to make description and interpretation easier, the group of images was divided into zones that we assume to correspond to hypothetical zoning of petroglyphs during their creation (Fig. 10).

Interpretation of the 3D model

Different types of petroglyphs form several technically, stylistically or semantically different zones. Attempting their interpretation and contextualisation requires restoring the petroglyph creation sequence from zone to zone in the most detailed and comprehensive way.

The central symbol of the first zone includes a zigzag formed by four double triangles, created by wide and deep notches. This zigzag is one of the most ancient petroglyphs in the relative chronology of the palimpsest (Fig. 11). It is damaged by the line between zones 1 and 5 at the bottom and by the 'foot' petroglyph at the top.

The second zone consists of a few zigzags and straight lines in the style that B. Mykhailov called 'surface dash style' (Mykhailov 2005: 78). Later, a sandal-shaped 'foot' petroglyph was incised through the lines.

In the third zone, a few short and wide horizontal notches have the same chronological position as the 'foot' petroglyph, and ten vertical notches were later incised. One of the lines is connected with a long notch in the sixth zone.

In the fifth zone, zigzags and 13 vertical and diagonal lines were made later than the line between first and fifth zones. Concurrently with them, due to numerous strokes, the front side of the figure was damaged, and two wide lines in the lower part of the figure were destroyed. The inclination of the leftmost notches that are close to the damage zone show that these lines were finished after the damage occurred.

The fourth zone contains two independent groups of images. The first one is a series of 12 vertical notches that was incised over the foot petroglyph. Later the series was damaged by a long vertical line that might have also destroyed a 13th notch. The line zones the last and probably the youngest group of triangles. Their lines are much narrower, a bit deeper, and they do not form a zigzag.

In the sixth zone, the zigzag is not connected with any groups of images; consequently, its chronological position is unknown. It is formed by shallow and wide notches and located far from other zigzags in the arrangement.

In the seventh zone, line and zigzag provide no

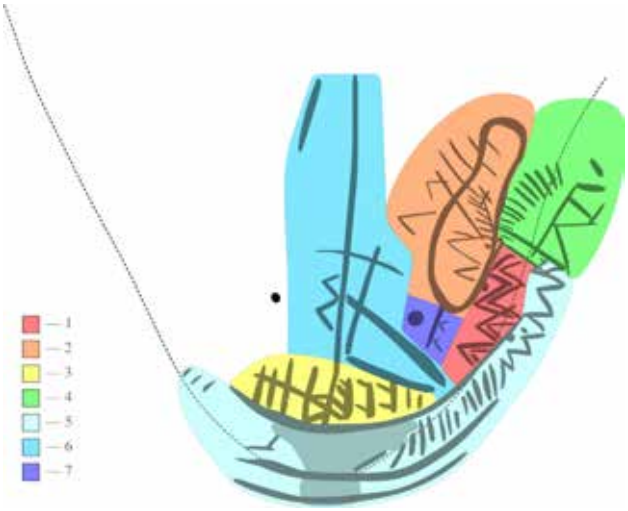

Figure 10. *Zoning of the petroglyphs of the palimpsest (by SR).*

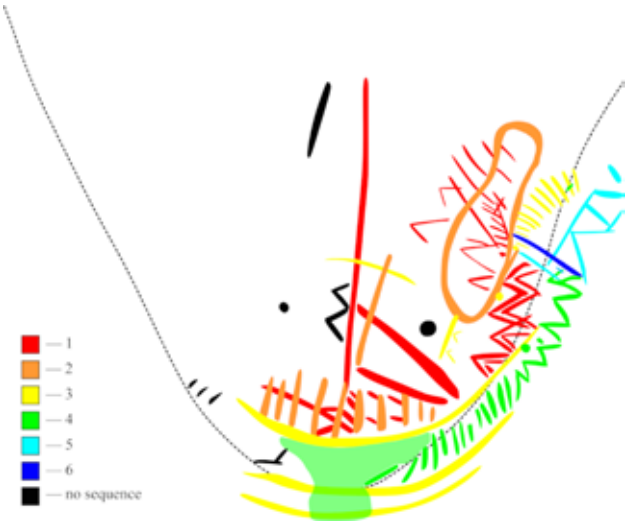

Figure 11. *Relative chronology (sequence) of the petroglyphs' creation, revealed from the analysis of mesh stratigraphy (by SR).*

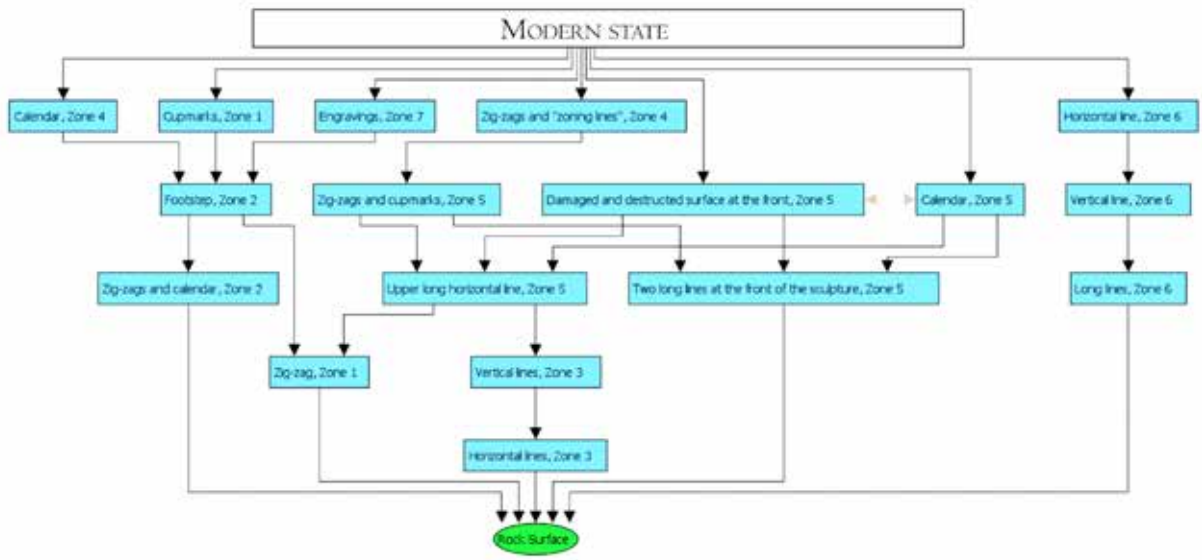

Figure 12. *Harris matrix of the petroglyph creation sequence (by SR).*

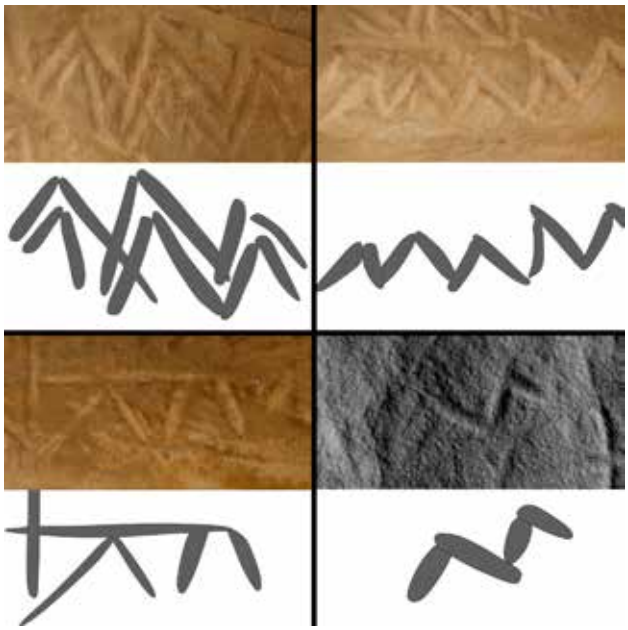

Figure 13. *Different types of zigzag ornament on the different zones of figure and their drawings: (a) zone 1; (b) zone 4; (c) zone 5; (d) zone 6 (by SR).*

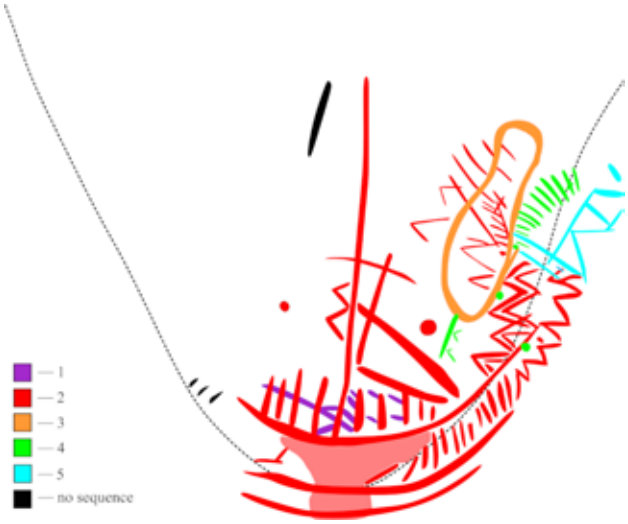

Figure 14. *A reconstructed sequence of creation of petroglyph groups, based on the interpretation of Harris matrix (by SR).*

chronological information other than that they were engraved later than the 'foot'.

In all the cases when cupules intersected a motif, the former are younger than the latter. The sequences can be presented in a Harris matrix for easy visualisation (Fig. 12).

Zigzag is the most frequent ornament in the arrangement (Fig. 13) and shared in other Kamyana Mohyla petroglyphs, though its semantic functions are hard to define. Significantly, zigzags from different groups are only slightly different, but one of them stands out technically (Fig. 13:3); its lines are deeper, sharper and form a V-shaped profile instead of U-shaped one. The unusual zigzag is younger than other zigzags or the 'foot', which could be relatively concurrent.

Taking into consideration the fact that described lines and zigzags are connected and probably form a composition, their spatial relation and numerous intersections, we can interpret the relative chronology of the petroglyphs and arrange them into chronologically and semantically related groups (Fig. 14). The relative chronology of the petroglyphs and the use of informed methods give access to the cultural and chronological interpretation of the figure.

Relative chronology of the palimpsest

A natural, slightly shaped sandstone protrusion was initially engraved with horizontal lines on the narrow part of the figure (Fig. 14, marked purple). These lines are the oldest in the relative chronological sequence. Vertical lines from zone 3 later superimposed them. The lines were created relatively concurrently with most of the petroglyphs. This phase (Fig. 14, marked red) also includes single and double zigzags. Two cupules and 13 vertical lines between two long ones were probably created concurrently. The series of intersecting and zigzag-shaped lines in the upper part of the 'snout' is probably of the same age.

The 'sandal' (Fig. 14, marked orange) belongs to the next stage of petroglyphs that is chronologically in-between two technically different groups of zigzags. It cannot be directly related to the groups mentioned above because of the features of the zigzags in the fifth zone (Fig. 14, marked blue).

The fourth chronological group consists of a row formed by 12 vertical lines, a short line with adjacent zigzag and three small cupules that are incised through sandal contours and other lines (Fig. 14, marked green). These petroglyphs were made later than the sandal but are technically different from younger ones that intersect and damage them.

A different technique marks the final engraving stage that includes two zigzags and a few long 'zoning lines'. Their notches are narrower and shallower than those from other zones (Fig. 11, marked blue).

The interpretation below permits reshaping this chronological sequence into two more-or-less reliable 'episodes' of the arrangement's creation based on its cultural and archaeological context.

Cultural and chronological interpretation of the object

According to B. Mykhailov, who was the first to interpret the figure, it is an early Bronze Age Vedic dragon or snake. The sandal was a symbol of a god hero Indra who defeated the animal. Mykhailov believed that the figure was created by representatives of Yamna or Catacombna cultures and drew parallels with images of feet on early Bronze Age stelae (1992: 102).

Having studied the palimpsest and obtained its relative chronology, we can re-interpret it more comprehensively. The motif of a sandal is one of the

Figure 15. *Singular 'sandals': (1) Vishap figure from location No. 55 of Kamyana Mohyla (by SR); (2) burial No. 2 of kurgan 8 near Khrystoforovka, Mykolayivska region (Ukraine) (after Dovzhenko 2009); (3) kurgan near the Maryino settlement (Crimea) (after Formozov 1969); (4) kurgan group No. V near the Petrashevka village, Poltavska region (Ukraine) (after Suprunenko 2010); (5) grotto near the Skelnovskiy village, Rostov region (Russia) (after Kiyashko et al. 2010).*

comparatively reliable chronological and cultural markers across the steppe zone of eastern Europe. It can be credibly associated with a particular period. It appears reasonable to start the interpretation from this petroglyph and consider other ones with an interpretation in mind.

'Sandal'

This petroglyph is one of the most definite shapes across the arrangement (Fig. 15.1). A distinguishable right footprint is near the base of the arrangement's left side. It damages some previously made linear petroglyphs. This 'sandal' was engraved using abrasion. It is 10.4 cm wide, and its longest part is 18.8 cm. The 'sandal's' smooth lines are a distinctive feature that makes its technique of engraving stand out among others used. Due to the relatively large size and thicker contour, the 'sandal' is remarkably different from other petroglyphs present and visually dominates them. Human foot images are numerous on the stones of Kamyana Mohyla (Fig. 16.1). Remarkably, the 'foot' in this arrangement differs from dozens of identical petroglyphs across Kamyana Mohyla in that it has no outlined toes and is probably an image of a foot with a shoe on (Mallory and Adams 1997: 545).

Many times petroglyphs of sandals were considered in isolation, even though this kind of image is relatively unpopular (Ravdonikas 1938; Formozov 1969; Castiglione 1970; Verner 1973;

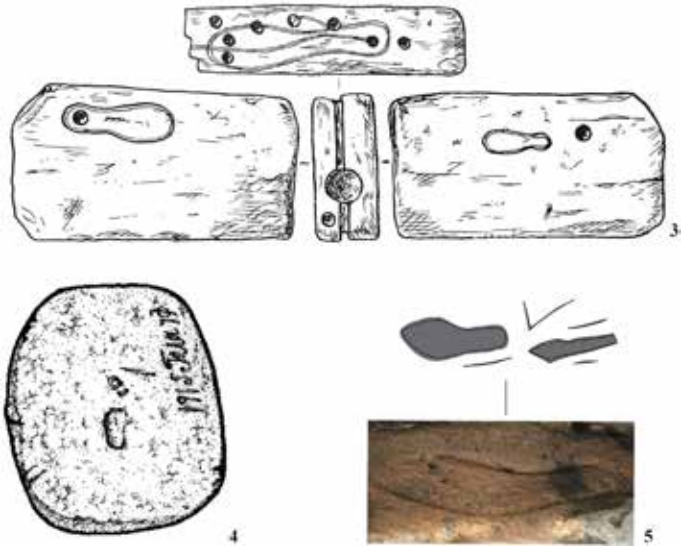

Figure 16. *Different 'foot' images of European sites: (1) block 34B of Kamyana Mohyla (after Titova 1982); (2) tomb 10.029 of PP4-Montelirio sector, Valencina de la Concepción burial (after Murillo-Barroso et al. 2015); (3) artificial cave No. 1 at Alapraia (Portugal) (after Heyd 2017); (4) necropolis of Almizaraque (Almería, Spain) (after Murillo-Barroso et al. 2015); (5) Belogrudovka I (after Telegin and Mallory 1994); (6) tomb 2 of a kurgan 11 near Konstantinovka village, Mykolayivska region (after Dovzhenko 2009); (7) Novoselovka (after Telegin and Mallory 1994); (8) Svatovo (after Korenevskiy 1999); (9) Kernosovo (after Dovzhenko 2009); (10) burial 18 of a kurgan 4 near Pryshyb village, Mykolayivska region (after Dovzhenko 2009).*

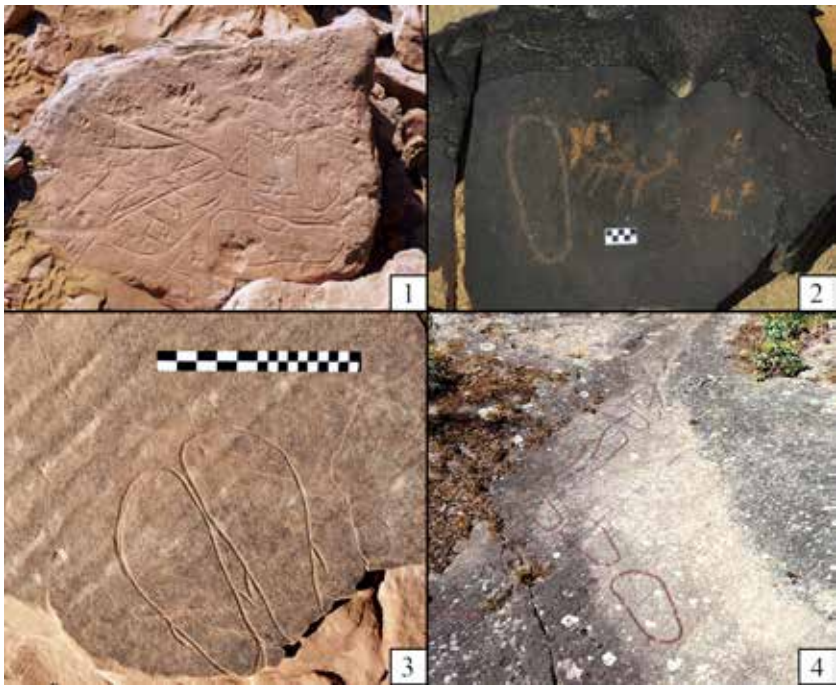

Figure 17. *Variant images of 'sandals': (1) from Panel 9 at site 17/07, Dakhleh Oasis, Egypt (after Polkowski 2018, Fig. 6); (2) ovaloid from Ramat Matred (after Eisenberg-Degen and Nash 2016, Fig. 3); (3) a pair of 'sandals' with a shoe detail (after Polkowski 2018, Fig. 4); (4) single-track trail from Boglösa in Sweden (after Skoglund et al. 2017, Fig. 10).*

Tonceva 1981; Titova 1982; Korenevskiy 1999). This image is not the most widespread; however, it occurs in many places around the world. The 'sandal's' geographic distribution includes both Africa (Fig. 17.1) and Eurasia (from the Canari Islands [Achrati 2003: 479] to Indonesia [Nash 2005] and from Norway [Nimura 2015] to Chad [Achrati 2003: 479]). The distribution is incredibly uneven. 'Sandal' images exist in Scandinavia, Bulgaria, Romania, northern Pontic region, the southern part of European Russia, on the coast of the White Sea and in the Iberian Peninsula. The biggest 'sandals' concentration can be observed in central Sahara (Tibesti, Ennedi, Nubia), Morroco, Algeria and Egypt. They also occur in Saudi Arabia, Yemen, Qatar, Oman, Palestine and Israel. They are highly variable in style and technique and have different chronological attribution.

Traditionally, the 'foot' pictures are divided into foot soles and footprints. Footprints are noticeable because of the drawn toes and the naturalistic image of a bare foot. Meanwhile, foot soles sometimes include shoe parts, e.g. ties (Skoglund et al. 2017: 289). 'Sandal' is a synonym to 'foot sole'. There is another popular classification model (Eisenberg-Degen and Nash 2016: 2), according to which sandal images must always include shoe parts; presence or absence of toes is distinctive of two different groups of footprints (Verner 1973: 28–39). The separate group of ovaloids that are oval or sub-rectangular shapes, sometimes crossed by a line (Fig. 17.1; see Achrati 2003: 481), should also be mentioned. Though their interpretation is quite different, those crossed with a line are usually considered as connected to sandals.

'Sandal' images in rock art occur in a diachronically very scattered distribution and have been used for centuries and millennia (Polkowski 2018: 371). This can be connected with the symbolic importance of the human foot, perhaps as a sign of mobility and freedom (Achrati 2003: 478).

At present, the only interpretation of Kamyana Mohyla 'foot' petroglyphs (excluding the considered 'sandal') is that they are footprints of a life-giving solar deity that wanders through the world and dates back to the middle of 4th and the beginning of the 3rd century BCE (Titova 1982: 14). A foot is a frequent kind of image on early Bronze Age anthropomorphous stelae, found in southern Ukraine, mostly at burial sites (Telegin and Mallory 1994) (Fig. 16.5–10). Having a description of 13 stelae featuring 'foot' images, S. Korenevskiy suggested their typology in the context of a cult among Eneolithic Bronze Age tribes in eastern Europe and the Caucasus region (Korenevskiy 1999). Anthropomorphous stelae in southern Ukraine also contain foot images, so-called sandals. The contouring technique is common for Kamyana Mohyla and stelae mentioned above (the only exception is a rare 'sandal' relief petroglyph on a figure in burial #18 of tumulus 4 near Pryshyb village of Mykolayivska oblast (Dovzhenko 2009: 132–135) (Fig. 16.10). In contrast to the 'foot' from Dragon Grotto, feet on stelae mostly occur in pairs. Usually, they are in the middle or lower part of a slab with their toes down. Semantic interpretation varies from a sign of status to a symbolic movement from the grave to the Underworld (Mallory and Adams 1997).

The tradition of picturing sandals in pairs also existed as a part of burial rituals in northern Africa. For instance, such images are located on a stone block in a tomb at Ti-n Affelfelen (Algeria). The same image occurs at the burial site of Akkar. Two stelae from the Wadi Ti-n Sharruma tomb in Libya contain pairs of ovaloids (Achrati 2003: 483).

Anthropomorphous stelae with foot petroglyphs from the south of Ukraine sometimes included the depiction of a waist, 'weapon' or 'staff'. In a fanciful interpretation, it has been connected with a shepherd-warrior, the lord of the Underworld, which is perceived as a pasture (Korenevskiy 1999: 71). The cult of feet is considered to be connected with the military-shepherd elite in figures of men, warriors, heroes, leaders or gods and has presumably become a

part of sacrificial symbols (Korenevskiy 1999: 75).

Similar individual sandals were found on a non-anthropomorphous slab near Mariino, Crimea (Formozov 1969: 167, Fig. 60). The slab was near a kurgan (tumulus), 1.40 m × 0.85 m in size and had individual cupules on it (Fig. 15.3). One more image was found near Khrystophorovka (Mykolayivska oblast) on the front side of an ornithomorphic stele from burial #2 in kurgan 8 (Dovzhenko 2009: 142—143). The stele is 1.30 m × 0.90 m and has numerous petroglyphs on it (Fig. 15.2). The character and the set of the images are very different from traditional iconography of stelae that were considered by S. Korenevskiy. One more image is a 21.5 cm long 'foot' (Fig. 15.4) in a small counter-relief that is almost in the middle of the front side of a rectangular granite block, found in kurgan V group near Petrashevka (Poltavska oblast) (Suprunenko 2010: 26–27). A horizontal thick-edge, deep line near the 'foot' might be an image of a staff (Telegin 1971: 4–7).

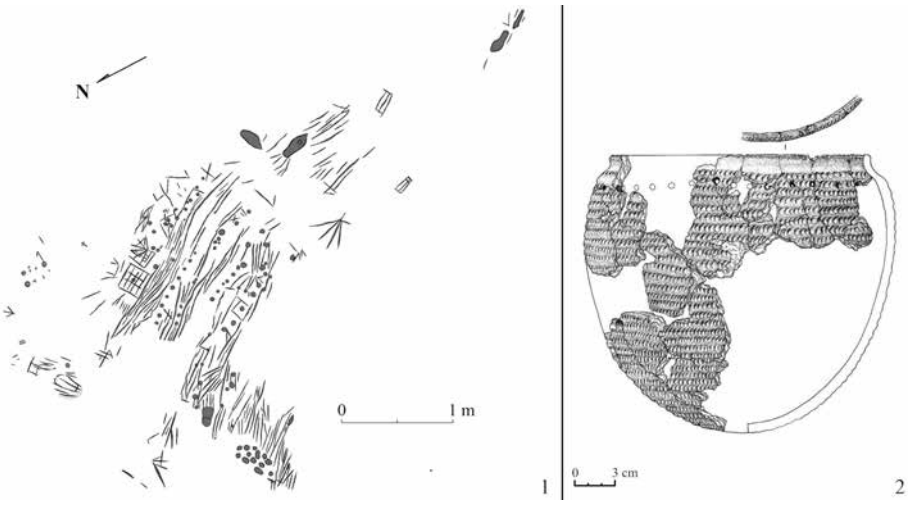

Figure 18. *Materials from the Lower Don region: (1) petroglyphs near Skelnovskiy village; (2) Yamnaya culture vessel from grotto near Skelnovskiy village (after Kiyashko et al. 2010).*

A grotto near Skelnovsky khutor in Rostov oblast, Russia, contains a finding relevant to the Kamyana Mohyla image (Kiyashko et al. 2010). The ground level of this small (5.4 m × 2.8 m) grotto, discovered in 2010, was entirely covered with petroglyphs. A 'foot' image was among them, away from the densest concentration (Fig. 15.5; 18.1). The look and engraving style of the two images compared are similar. The only differences are that the image near Skelnovskiy khutor is a left footprint, and it does not dominate visually over other elements of a composition. This image also has an angular line engraved nearby that might be a staff. A cultural layer that was studied along with these images suggests their significance. The layer contained quartzite tools for making petroglyphs and a broken ceramic vessel presumably belonging to the Yamna culture (Fig. 18.2). Kiyashko et al. (2010: 16) consider the complex of petroglyphs to also belong to the Yamna culture, and petroglyphs behind the 'foot' are what they consider resembles a Yamna culture knife.

Additional information concerning the interpretation and chronology of 'sandals' can be gained from the analogies from northern Africa and Near East. The appearance of a 'sandal' in Egyptian rock art is dated back to the Old Kingdom (2686–2181 BCE). The tradition of its engraving stops only during Christian and Islamic time (Polkowski 2018: 371). The early instances of such petroglyphs are known among the images from Dakhleh oasis, where they were pictured on stones near the houses (Fig. 17.3; see Polkowski 2018: 373). Most of these images are convincingly dated to Roman times. Petroglyphs in Ramat Matred (Negev Desert) belong to this period (Eisenberg-Degen and Nash 2016: 7). The sandal is a quite popular picture in Egyptian temples of the Roman period (Castiglione 1970: 120). There are many ways of Egyptian sandal petroglyph interpretation and some of them deserve consideration. Sandals are sometimes considered as pilgrims' signatures that mark their appearance in a place; protective symbols; gratitude for healing; a trace of a god; an incarnation of a human soul. According to P. Polkowski, engraving the sandals in Dakhleh Oasis was the traveller's way to make the environment safer by summoning the gods. Petroglyphs from Egyptian temples of the Roman age serve the same purpose. Those of temple acolytes who were incapable of writing a name or a signature drew a sandal to stay in a deity's presence (Polkowski 2018: 376).

Taking into consideration all the above analogies, the clues about cultural attribution of the Kamyana Mohyla sandal are as follows:

- Bone, stone and ivory sandal finds (Fig. 16.3, 4) inside burials in the south of Iberian Peninsula are evidence that sandal images appear during the Eneolithic–early Bronze Age (Murillo-Barroso et al. 2015: 588–589). A sandal on a gold sheet from the Valencina de la Concepción burial complex (Fig. 16.2) is the most outstanding. Some features relate the complex to Yamna and Corded Ware cultures — its absolute age (2875–2700 BCE), the size of tumuli, a right-side crouching position of the body, east-western orientation, flint tools in the burial and painting with red pigmentation (Heyd 2017: 354). Later on (1700–500 BCE), the tradition of foot petroglyphs spread to Scandinavia, resulting in more than 400 of such images, which are mostly concentrated in Sweden (Fig. 17.4; also see Nimura 2015: 57).
- The closest analogy to the 'sandal' from Vishap (Dragon) Grotto is from Skelnovskiy khutor. By

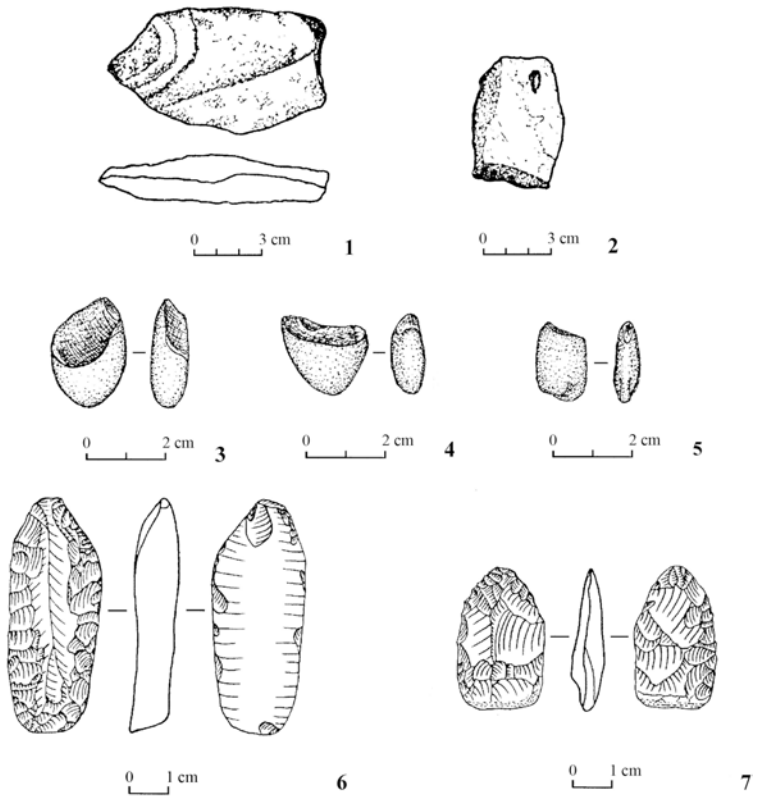

Figure 19. *Tools for petroglyphs creation from the Kamyana Mohyla: (1, 2) sandstone (after Danilenko 1986, Fig. 25); (3–5) sharpened quartzite pebbles (after Dzhos 2017: Fig. 4); (6, 7) flint tools with the use wear from incising sandstone (after V. Dzhos 2017: Fig. 4).*

the materials of related cultural level, it is believed to be of the Yamna culture.

- Stelae with paired sandals related to burial sites in southern Ukraine are also dated to early Bronze Age by the features of a burial ritual.
- Finds that are chronologically close to the Yamna culture were found within Kamyana Mohyla hill. O. Bader, M. Rudinskiy, V. Danilenko, B. Mykhailov and V. Dzhos studied a few locations near Bull Grotto, containing assemblage from that period (Rudinskiy 1961: 113–118; Danilenko 1986: 69–70; Mykhailov 2005: 67–70; Dzhos 2017). They appeared to be the remnants of a redeposited cultural level of a settlement on the north-western slopes of Kamyana Mohyla hill (Dzhos 2017: 30). Along with flint tools, typical for late Eneolithic and early Bronze Age, and fragments of polished stone figures, many tools to make petroglyphs were found (Fig. 19).
- Yamna culture materials are found across Kamyana Mohyla and nearby (Terehozhkin 1960). A stone burial that was 200 m away from the site (found during 2018 field season) contained bones of a young crouched man with no inventory and was dated to approximately 2758–2732 calBCE.

Therefore, the sandal appears to have a chronological attribution to the final Eneolithic–early Bronze Age (3200–2600 BCE) and was created by people of the Yamna culture. Single sandal images seem to relate mainly to sacral places, paired ones to burial sites. Similar images, found in chronologically equal archaeological sites that are thousands of kilometres apart, are evidence that the 'cult' of sandals spread across Europe and northern Africa at the beginning of the 3rd millennium BCE. Such spread of sandal imaging, regardless of a specific interpretation, might be connected with a growing mobility of humans during that time (not least because of wheeled transport). Rapidly exploring new territories, humans tried to leave the signatures of their own and their gods on new lands.

That is the key to a chronological attribution and re-interpretation of other petroglyphs on the figure. The petroglyphs that are older than the 'sandal' could be connected with cultural levels of nearby sites, ranging from final Palaeolithic to early Bronze Age. The upper chronological limit narrows down the search for analogies and simplifies the task.

The petroglyphs from the fifth stage (the long line in zone 4 together with the narrow zigzag (Fig. 13.3) are relatively younger than the 'sandal'. However, according to Korenevskiy (1999) and Telegin (1971), they can also be associated with Yamnaya culture habitation and mark the same period. Thus, the petroglyphs from the last three stages might belong to the same chronological interval. On the contrary, the first two layers were created before. Their contextual interpretation is provided below. Therefore, we assume that horizontal lines from zone 3 were created concurrently (in terms of cultural interpretation) with the vertical lines from the same zone and zigzag petroglyphs. This is because of their compositional features, similar shape and topological relations.

Zigzags and other lines

The realistic and reasonably detailed fish head in Dragon Grotto consists of the natural protrusion marked with the engravings and should belong to a catfish (Fig. 20.1), one of the biggest river fishes in Ukraine in the past ten thousand years. However, the search for analogies is complicated by the lack of large fish sculptures in European pre-History. Several small stone and bone figures were found in Mesolithic sites within the forest territory of European Russia (Oshibkina et al. 1992: Fig. 42, 52). Some fish images in this region are related to the Neolithic and Eneolithic (Oshibkina et al. 1992: Fig. 122–124). For instance, many fish bones, especially those of catfish and sturgeons, were found within Sakhtysh site (Oshibkina et al. 1992: 96).

Images and fish-shaped stone churingas, dated to Mesolithic and Neolithic age, are also found at Kamya-

Figure 20. *Animals believed to be engraved at Kamyana Mohyla: (1) catfish (*Silurus glanis*); (2, 3) viper (*Vipera ursinii*).*

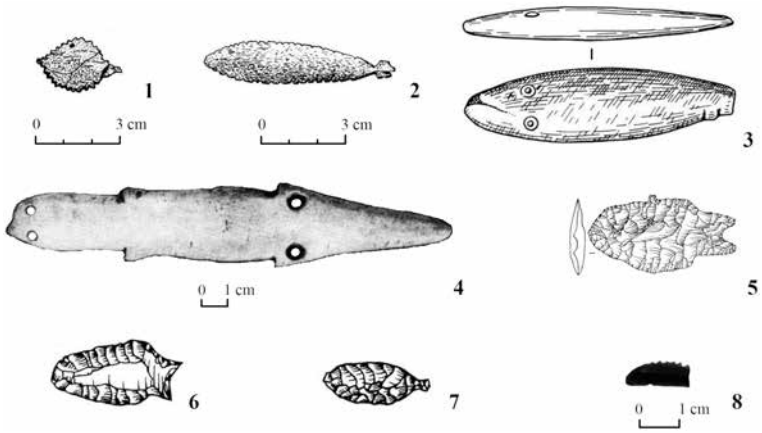

Figure 21. *Fish figurines dated to Mesolithic (1, 2) and Neolithic (3–8): (1, 2) Lower Veretie; (3, 4) Sakhtysh 1; (5) Sakhtysh 2; (6) Ronskoe 1; (7) Synya Gora; (8) Kamyana Mohyla 1 (1–4) bone; (5–8) flint; Nos 3, 5, 6, 7 not to scale (1–7 after Oshibkina et al. 1992; 8 by N. Kotova).*

na Mohyla (Rudinskiy 1961: Fig. 16, 69; Danilenko 1986: 72–87). Some of them depict large fishes (for instance, churinga found by Rudinskiy in 1952). According to Danilenko, a natural formation with incised images from Northern Grotto in Kamyana Mohyla resembles a catfish. Stone fishes in Siberia and *vishaps* in Transcaucasia, which are connected with the elements of water, water depths and the Underworld, are similar to the objects as mentioned above (1986: 66).

Some fish-resembling portable objects are known among Khakassian stone figures. One figure near Styra Lake is shaped like a massive cigar that is oval in cross-section. One end is wider and flattened, so it resembles a broad head of a fish. Aside from resembling a fish, this figure has its surface covered with petroglyphs that are typical for rock art near the Yenisey (Okladnikov 1975: 59, Fig. 1).

Small stone fish baits are known in Neolithic cultures of this region (Kyzlasov 1986: Fig. 1.16). Clothes decorations made of bone in the form of small fish were found in burial sites of the Kuznetsko-Altayskaya culture that is connected through genetics with the Neolithic of the Baikal region (Kungurova 2004: 11, 15).

Most small bone and stone figures are related to the Neolithic of the Baikal region (5000–4000 BCE). S. Studzitskaya divides them into three groups: stone fish figures that served as bait, bone and stone figures that served as amulets and pendants, single-side clothes decoration made of bone in the form of a fish (2011: 42). The Neolithic population of Baikal region pictured trade fish, and a fish of average value, the burbot, is the most represented. It is a central figure in shaman cults, mythology and folklore of Siberians. It was also related to the Underworld. According to Studzitskaya, its serpent-like body and 'disgusting' appearance stirred the imagination of ancient people (2011: 47).

The mentioned fish images from Russian territory are very different from Kamyana Mohyla fish (Fig. 21) in size, materials and style. However, we should mention a trapezoid fish figure made of flint with teeth on its narrow edge was found in an early Neolithic layer of Kamyana Mohyla 1 settlement (Fig. 21.8). It could have had similar functions to the finds from the Eurasian forest zone and served as fishing bait.

Large stone fish/human hybrids stone figures (Radovanivic 1996: Fig. 3.55, 3.60) are known within late Neolithic–early Eneolithic sites in Iron Gates on the river Danube from about 6300 cal BCE. Palaeodietary data indicates a strong reliance on fish throughout the Mesolithic period. Stable isotope data is evident that during the early Neolithic period, at least a part of the population abandoned reliance on fish that characterised the Mesolithic diet. This might be connected with an incoming Neolithic population with a manufacturing economy. Since this change coincides with the appearance of 'fish/human hybrid' depictions, this dietary change has been interpreted, although not entirely, as a consequence of specific prohibitions, including taboos against eating at least certain types of fish (Borić 2007). Figures could picture the stages of metamorphosis, from a dead person to a 'fish ancestor' (Borić 2005). Remarkably, these figures were found only in Lepenski Vir settlement (Srejović 1972). Its dwellers specialised in catching *Huso huso*, the largest of sturgeons in the Danube. The figures within the site resemble this very species (Živaljević 2012: Fig. 5.6). People elsewhere of the same time, from Vlasac (specialisation in catching carp [*Cyprinus carpio*]) and Padina (specialisation in catching catfish [*Silurus glanis*]), did not make such figures (Živaljević 2012). Lepenski Vir sculptures are stylistically different from the Kamyana Mohyla 'catfish' figure.

Mykhailov looked for analogies differently. In his works devoted to the Dragon Grotto, he noted that

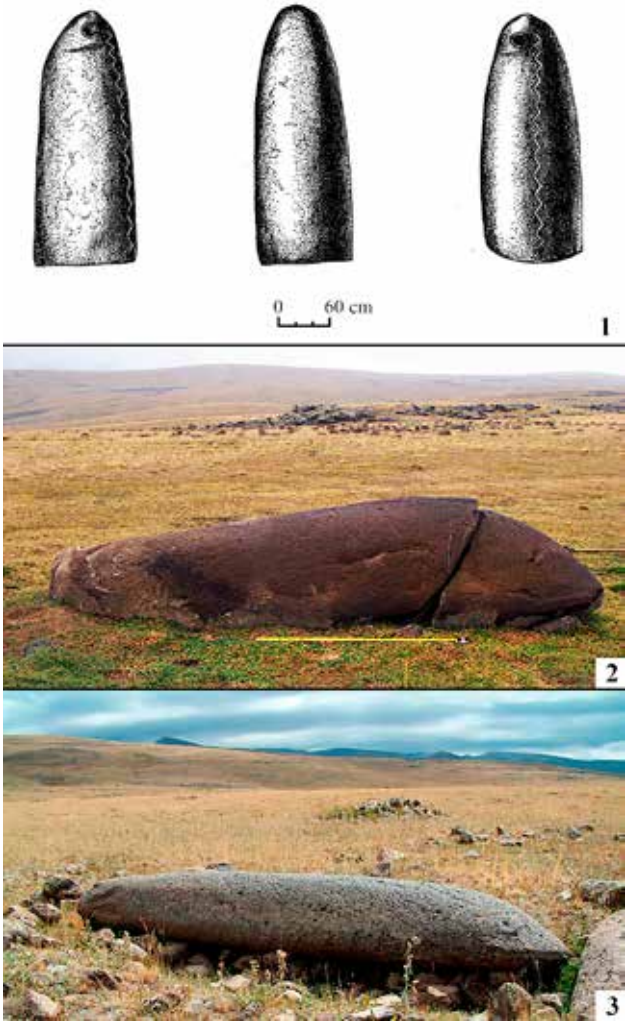

Figure 22. Vishaps of the southern Caucasus: (1) after Narimanishvili et al. (2015); (2, 3) after Petrosyan (2015).

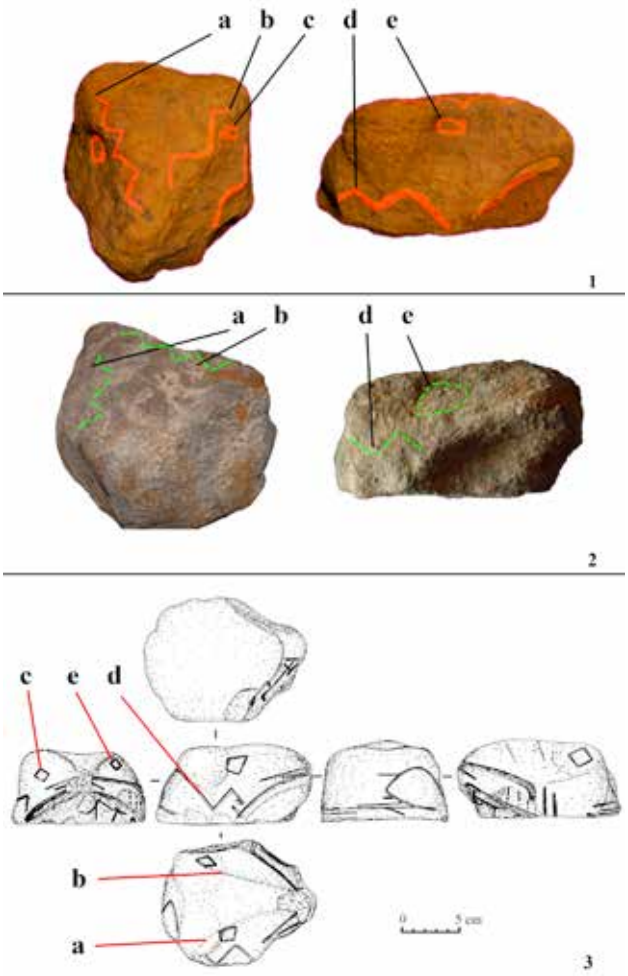

Figure 23. Snakehead sculpture made of sandstone found in the Mesolithic layer of Kamyana Mohyla 1 settlement (after Kotova et al. 2018): (1) 3D model with reconstructed ornamentation that is invisible without microscopic tools (by SR); (2) image (by N. Kotova); (3) preliminary drawing (by N. Kotova before microscopic examination).

the figure is similar to Caucasian serpent-fish dragons or *vishaps* (1992: 99; 1993: 112). *Vishaps* in Armenia are large stone figures or stelae, most of which are interpreted as images of chthonic fishes (Marr and Smirnov 1931; Piotrovskiy 1939; Abrahamian 2015; Tumanyan 2015).

These sculptures are different in their purpose and dating. Some have relief images on the belly and their tail untouched, so they should have been in a vertical position. Other fish figures with flat or concave belly without relief should have been laying horizontally (Abrahamian 2015: 124). Different scientists presume that vishaps were functional from 6000–5000 BCE to 300 BCE and the Bronze Age is considered to be the main period of their use. The middle of the 2nd millennium BCE and onward, especially the beginning of the 1st millennium BCE, is when *vishaps* were being reconsidered in the context of the most popular 'water' hypothesis (Abrahamian 2015: 125).

N. Marr was the first to notice that some Armenian stone fishes are endemic prototypes of a catfish, *Luciobarbus* (Marr and Smirnov 1931: 93). Lying fish-resembling figures could initially be made of water-worn stones and serve as water dividers (Abrahamian 2015: 128, 131). The most ancient type of Caucasian finds is fish-resembling stelae that have no petroglyphs other than fish and water symbols on them (Tumanyan 2015). They seem to relate the most to the Kamyana Mohyla arrangement (Fig. 22).

A snakehead sculpture from the Mesolithic level of Kamyana Mohyla 1 settlement (Fig. 23) (Kotova et al. 2018) also resembles the image considered here. It is of similar material and creation technique (smooth lines incised in sandstone). We interpret the Kamyana Mohyla figure as a catfish and the snake as a venomous steppe viper (Fig. 20.2, 3) with knobs on its head and an arc on the back of the head. Remarkably, zigzags are used on both figures. The snake's head is dated to 8379±160 calBCE by charcoal from a fireplace (Kotova et al. 2018: 1).

A fish head from location #55 in Kamyana Mohyla is decorated with double-line zigzag that has some interesting analogies. While singular and multilinear

zigzags have broad expansion and dating range, zigzags made of two lines are rarer. The double zigzag is known on European Mesolithic bone tools, stone and bone pendants and a unique wooden idol from Shygyr peat bog (Ural, Russia). This large sculpture is dated to 9600–9000 calBC (Zhilin et al. 2018: Fig. 1). The double zigzag is also known in the forest Mesolithic of Russia, namely in the Veretye culture that is rich in ornamented bone products (Fig. 24.3) (Oshibkina et al. 1992: Fig. 16.10). This zigzag is also found on small ornamented stones (churingas) from Zamostye 2 camp near Zablolotskoye Lake in Sergievo-Posadkiy district of Moscow oblast (Fig. 24.4–7) (Sidorov and Engovatova 1998: Fig. 1.26, 32). Double zigzags are among the ornaments on Mesolithic and early Neolithic bone figures from this camp as well (Sidorov and Engovatova 1998, Fig. 3.2; 4.1). This zigzag was used to decorate stone pendants and bone figures dated to 7000 calBCE, found on late Mesolithic sites of the lower Don river (Fig. 24.1–2) (Gorelik et al. 2016). This element is also on a bone tool from the Mesolithic level of Icoana settlement in Iron Gates on the river Danube (Fig. 21.8) (Plonka 2003: Fig. 28.2, after Boroneant 1973).

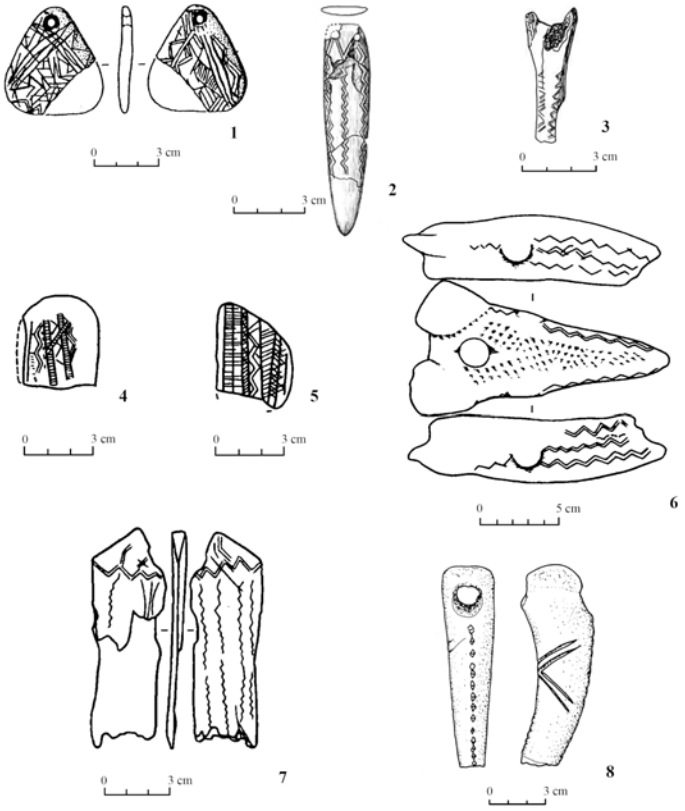

Figure 24. *Double zigzag ornamentation: (1, 2) Razdorskaya 2 (after Tsybrij 2004); (3) Sukhoe camp (after Oshibkina et al. 1992); (4–7) Zamostye 2 camp (after Sidorov and Engovatova 1998); (8) Icoana, level 1 (after Plonka 2003).*

Double-zigzagged bone and stone finds are known from late Mesolithic and Neolithic sites of Dnieper region. Fragments of spear/dagger bone tips from Surskoy Island 1 and Igren' 8 settlements have engraved double parallel and crossed zigzag ornament compositions on them. Double zigzag compositions are known on talc tools from Poltavka and Kizleviy 5 and a bone bracelet fragment from Vasilyievskiy II burial site (Fig. 25).

Relief images on stone pillars of Gobekli Tepe, dated to the earliest phases of Pre-pottery Neolithic (PPNA and PPNB) are worth mentioning. Some of them depict snakes, and their bodies resemble parallel zigzags (Schmidt 2006: Fig. 44–45; 91–92). Some *vishaps* in Armenia also have parallel relief lines on them, which are considered to be water streams (Piotrovskiy 1939: 5–11).

During Neolithic and early Eneolithic times, the double zigzag was used on pottery ornaments in the very same regions where it was used to decorate Mesolithic bone and stone finds, lower Don (Kotova 2003: Fig. 72.5; 73.5; 78.10) and forests near the river Volga (Sidorov and Engovatova 1998: Fig. 7.6, 11). Previously unknown double horizontal or numerous vertical zigzag ornaments appeared on the pottery of that period within Dnieper and Azov Sea regions (Telegin 1991: Fig. 55.1, 2; Kotova 2015: Fig. 11.1; 14.4).

Considering the modern state of the archaeological record, it is reasonable to

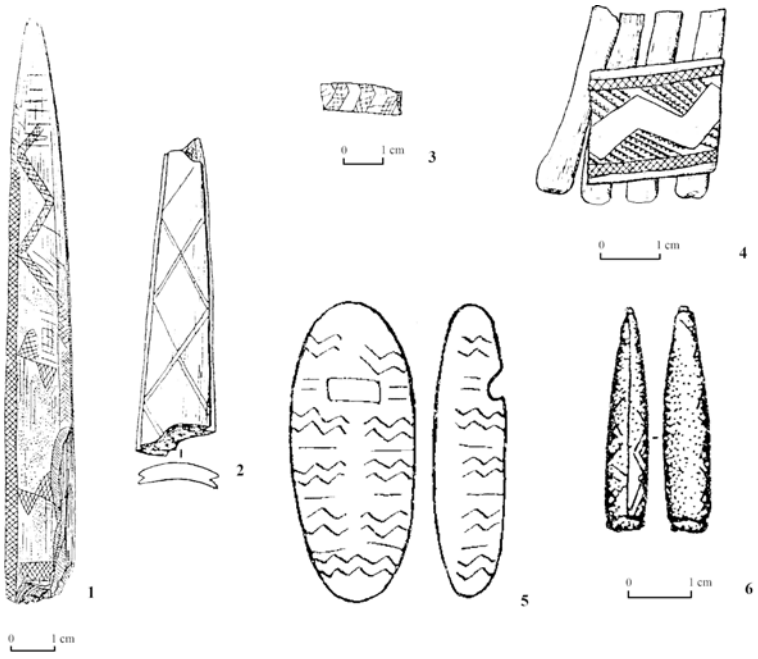

Figure 25. *Double zigzag ornamentation from the territory of Dnieper region: (1) Surskoy Island 1 (after Danilenko 1950: Fig. 1. 1); (2, 3) Igren' 8 (after Telegin 2000: Fig. 20.15, 41); (4) Vasylievka (after Telegin 1991: Fig. 15); (5) Poltavka (after Telegin 1968: Fig. 50.1); (6) Kizleviy 5 (after Tuboltsev 2005: Fig. 7.15). Nos 2 and 5 are not to scale.*

suppose that the north-western Pontic area had already been inhabited by a range of different cultural groups upon the arrival of central European early farmers (including complex, river-oriented societies). Similar river-oriented cultures inhabited the shores of large European rivers in the first part of the Atlantic period — the Schela Cladovei-Lepenski Vir culture on the Danube (Bartosiewicz and Bonsall 2004; Bonsall et al. 2004), Buh-Dniester culture in the Dniester and southern Buh valleys (Danilenko 1969; Markevich 1974; Kiosak and Salavert 2018) the Surs'k culture on the Dnieper (Demchenko 2016), and the Rakushechny Yar on the Don (Gorelik et al. 2016). These groups appeared mostly in the rapid-rich parts of the river valleys. They share several material characteristics, most likely due to their shared tendency to exploit river resources. Their role in regional Neolithisation was likely different from the role of mobile hunter-gatherers.

Since fishing provided food to the entire region, water- and fish-related religious beliefs supposedly appeared in the life of these Mesolithic and Neolithic populations (Neprina 1988; 1991; Kryzhevskaya 1991; Tsybrij 2004). Consequently, corresponding images appeared. Double zigzag, as ideogram of water, probably was one of them.

Some Lower Dnieper and Donets region settlements of this period were catfish-oriented (Bodyanskiy 1949: 255; Danilenko 1950: 129; Belanovskaya 1975: 107; Telegin 2000: 70). Consequently, this fish had the importance of being a primary source of food, and it has been reflected in sacral beliefs and palaeoart that could be connected with water.

The complex of older petroglyphs from the Kamyana Mohyla figure has numerous analogies in the rock art of Eurasia. This involves both the figure's semantic interpretation as a chthonic fish, catfish and features of individual elements (e.g. double and single zigzags). Having analysed all the materials, we define the figure as Mesolithic or early Neolithic. Consequently, we can date the catfish figure to the end of the 9th–8th millennia BCE and regard it as a part of Kamyana Mohyla Mesolithic and Neolithic sacral complex. Cultural, social and economic conditions of that period correspond to the preconditions of the creation of numerous fish images across Europe and Asia.

Conclusions

That is the way the Kamyana Mohyla palimpsest was interpreted. A unique and complex petroglyph assemblage, previously associated with Indo-European mythology, revealed its nature only after thorough and comprehensive study. Ultimately, the result exceeded all expectations and enabled us to define the two periods when the Dragon Grotto figure was created.

The sandstone protrusion of prominent ellipsoid shape attracted the attention of ancient artists during the late Mesolithic period when the fishing-oriented societies emerged. They engraved the symbols that were typical for corresponding chronological and cultural context — single and double zigzags, lines (usually in a group of 13?), and horizontal lines can be interpreted as a mouth and two cupules as eyes. With all these marks, corresponding to the first two layers or phases of the Harris matrix, the protrusion became a Mesolithic fish head. The three last layers of petroglyphs were created more than four millennia later, during the late Eneolithic or early Bronze Age — the 'sandal' print and related marks form the second 'layer' of the palimpsest. Thus, numerous petroglyphs and five relative chronological stages belong to two episodes of the figure's creation and modification.

Fish image sacralisation during the Mesolithic is probably why dwellers from nearby settlements have shaped the sandstone protrusion and turned it into a catfish, covered with zigzags and other geometric ornaments. Zigzags are found on rock art objects from Kamyana Mohyla that are of definite Mesolithic origin. A huge catfish, dated to 9th–7th millennia BCE, is from a vast range of Mesolithic and Neolithic finds and shares its context with sites across central Europe, Azerbaijan and Siberia. An image of a particular chthonic fish (catfish, sturgeon, trout, ruffe and others, depending on the region) could be one of the most ancient and later it was ousted by an image of a fantastic fish-resembling creature that holds the Earth (Berezkin 2015: 72).

Thousands of years later, artists from the Yamna cultural group gave a new life to the figure. They appeared near Kamyana Mohyla at the beginning of the early Bronze Age (3200–2600 BCE) and embodied their art traditions and symbolic images across the whole site and on the catfish in particular. Yamna culture representatives augmented the catfish with the 'sandal' and a few zigzags, which were different from the symbols of their ancestors. Perhaps they regarded the fish head as Stone Age people did — as a creature of the Underworld. Consequently, they added a semantically appropriate motif to the figure.

We secured our results only due to an unbelievable combination of circumstances — accessibility of the grotto, weather conditions, individual notch intersections, availability of required methods, combination of multidisciplinary approach and classical archaeological research, and many more factors that were mandatory to include the unique figure from Kamyana Mohyla into a Eurasian rock art context. The bottom line is, this is only one of the hundreds of locations across Kamyana Mohyla, which has been only barely studied and partially published. A complete and comprehensive study is yet to come.

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REFERENCES

Abrahamian, L. 2015. Archetype of the vertical and the stone vishaps. In A. Petrosyan and A. Bobokhyan (eds), *The Vishap stone stelae*, pp. 121–135. 'Gitutyun' Publishing House, Yerevan.

Achrati, A. 2003. Hand and foot symbolism: from rock art to the Qur'an. *Arabica* 50(4): 464–500.

Arcá, A. 2018. 3D modeling demonstrates that some cup-marked boulders were squared off. In *20th International Rock Art Congress IFRAO 2018. Book of abstracts*, p. 219. Darfo Boario Terme, Italy.

Bartosiewicz, L. and C. Bonsall 2004. Prehistoric fishing along the Danube. *Antaeus* 27: 253–272.

Belanovskaya, T. 1975. To the question of fishing during the Neolithic of Lower Don. *Brief Communications of the Institute of Archaeology* 141: 107–111 [in Russian].

Berezkin, Yu. 2015. Zoomorphic world-support and the vishaps — adversaries of the Thunder-God. In A. Petrosyan and A. Bobokhyan (eds), *The Vishap stone stelae*, pp. 59–80. 'Gitutyun' Publishing House, Yerevan.

Bodyanskiy, O. 1949. Neolithic camp on the Shulayev island. *Archaeology of Dnieper region* 2: 253–263 [in Russian].

Bonsall, C., G. Cook, R.E.M. Hedges, T.F. Higham, C. Picard and I. Radovanović 2004. Radiocarbon and stable isotope evidence of dietary change from the Mesolithic to the Middle Ages in the Iron Gates: new results. *Radiocarbon* 46(1): 293–300.

Borić, D. 2005. Body metamorphosis and animality: volatile bodies and boulder artworks from Lepenski Vir. *Cambridge Archaeological Journal* 15(1): 35–69.

Borić, D. 2007. Images of animality: hybrid bodies and mimesis in early prehistoric. In C. Renfrew and I. Morley (eds), *Material beginnings: a global prehistory of figurative representation*, pp. 89–105. The McDonald Institute for Archaeological Research, Cambridge.

Boroneant, V. 1973. Recherches archeologiques sur la culture Schela Cladovei de la zone des 'Portes de fer'. *Dacia* 17(NS): 5–39.

Castiglione, L. 1970. Vestigia. *Acta Archaeologica Academiae Scientiarum Hungaricae* 22: 95–132.

Chippindale, C., J. de Jongh, J. Flood and S. Rufolo 2000. Stratigraphy, Harris matrices and relative dating of Australian rock art. *Antiquity* 74: 285–286.

Danilenko, V. 1950. To the question of the early Neolithic of the south Dnieper region. *Archaeology of Ukraine* 3: 119–147 [in Ukrainian].

Danilenko, V. 1969. *Neolit Ukrainy: glavy drevnejshej istorii Jugo-Vostochnoj Evropy*. Naukova dumka, Kiev [in Russian].

Danilenko, V. 1986. *Kamyana Mohyla*. Naukova dumka, Kiev [in Ukrainian].

Demchenko, O. 2016. The natural environment and adaptive strategy of the population of the Dnieper rapids region in the late Mesolithic–Neolithic period. *Stratum Plus* 2: 175–191 [in Russian].

Dovzhenko, N. 2009. Stone statuary sites of the north Pontic region early and middle Bronze Age. In R. Zabashta R. (ed.), *Ancient sculpture and portable art of Ukraine, Vol. 3. Bronze Age*. Rodovid, Kiev [in Ukrainian].

Dzhos, V. 2017. Results of rescue excavations of the Eneolithic site on the 'Kamyana Mohyla ritual complex' archaeological site in 2016. *Herald of the 'Kamyana Mohyla' Reserve* 2: 30–35.

Eisenberg-Degen, D. and G. H. Nash 2016. Foot/sandal prints and ovaloids in the rock art assemblage of Ramat Matred, the Negev Desert, Israel. *Journal of Arid Environments. Special Issue on Rock Art in Arid Environment* 143: 50–57.

Formozov, A. 1969. *Sketches on pre-Historic art*. Nauka, Moskow [in Russia].

Gladilin, V. 1969. Die Felsbilder der Kamennaya Mogila in der Ukraine. *Jahrbuch für prähistorische und Ethnografische Kunst* 22: 82–92.

Gorelik A., A. Tsybrij and V. Tsybrij 2016. Neolithisation in the NE Sea of Azov region: one step forward, two steps back? *Documenta praehistorica* 43: 139–160.

Graff, C., K. Piquette, R. L. L. De Bruycke and A. Kelany 2018. Comparing the use of R.T.I. (Reflectance Transforming Imagery) and photogrammetry in wadi Abu Subeira (Assuan, Egypt): what technology for which context? In *20th International Rock Art Congress IFRAO 2018. Book of abstracts*, p. 130. Darfo Boario Terme, Italy.

Hermon, S., M. Polig, J. Driessen, G. Jans and J. Bretschneider 2018. An integrated 3D shape analysis and scientific visualization approach to the study of a late Bronze Age unique stone object from Pyla-Kokkinokremos, Cyprus. *Digital Applications in Archaeology and Cultural Heritage* 10: e00075.

Heyd, V. 2017. Kossinna's smile. *Antiquity* 91(356): **348**–359.

Kiosak, D. and A. Salavert 2018. Revisiting the chronology of two Neolithic sites in eastern Europe: new radiocarbon dates from Melnychna Krucha and Kamyane-Zavallia (southern Buh region, Ukraine). *Revista Archeologica* 14: 116–131.

Kiyashko, V., V. Tsybrij, A. Tsybrij, T. Tsybrij, A. Zakharikov, A. Orlenko, A. Ozerov, G. Abakumov and T. Abakumov. 2010. *Petroglyphs near Skelnovskiy village*. NaukaPRO, Rostov-na-Donu [in Russian].

Korenevskiy, S. 1999. Foot cults of the south of eastern Europe and near Caucasian region tribes during Eneolithic and Bronze Age (archaeological sources and some issues of ancient beliefs development). *Funeral rite. Reconstruction and interpretation of ancient ideological ideas*, pp. 54–77. Eastern literature of RAS, Moskow [in Russian].

Kotova, N. 2003. *Neolithization in Ukraine*. BAR International Series, Oxford.

Kotova, N. 2015. *The most ancient pottery of Ukraine*. Maidan, Kiev–Kharkiv [in Russian].

Kotova, N., D. Kiosak, S. Radchenko and L. Spitsyna 2018. Microscopic examination of Mesolithic serpent-like sculptured stones from southern Ukraine. *Antiquity* 92(366): E2.

Kotova, N., O. Tuboltsev, D. Kiosak, L. Spitsyna, S. Makhortykh, W. Tinner, E. N. Nielsen and V. Dzhos 2017. Preliminary results of excavations at the multilayer Kamyana Mohyla 1 site (2011–2012). In S. Makhortykh and A. de Capitani (eds), *Archaeology and paleoecology of the Ukrainian steppe*, pp. 28–51. FOP Filyuk, Kiev.

Kryzhevskaya, L. 1991. Fishing in the Russian steppe Neolithic. In N. Gurina (ed.), *Fishing during Mesolithic–early Metal*

Age in the forest and forest-steppe zones of eastern Europe, pp. 116–122. Nauka, Leningrad [in Russian].

Kungurova, N. 2004. Female costume during the 4th millennia BC (based on the material of Kuznetsko-Altaiskaya culture burials). *Archaeology, Ethnography and Anthropology of Eurasia* 2(18): 11–20 [in Russian].

Kyzlasov, L. 1986. *Ancient Khakasiya.* Moscow University Press, Moscow [in Russian].

Marr, N. and Ya. Smirnov 1931. Vishaps. *Proceedings of the State Academy of the History of Material Culture*, vol. 1. Leningrad [in Russian].

Mallory, J. P. and D. Q. Adams (eds.) 1997. *Encyclopedia of Indo-European culture*. Fitzroy Dearborn Publishers, London–Chicago.

Markevich, V. 1974. *Bug-Dniester culture in Moldova territory.* Stiinta, Chisinau [in Russian].

Mélard, N. 2010. L'étude microtopographique et la visualisation 3D dans l'analyse de gravures préhistoriques — L'exemple des pierres gravées de La Marche. *In Situ*, doi: 10.4000/insitu.6837.

Mélard, N., C. Boust, G. Cogne and A. Maigret 2016. Comparison of imaging techniques used in the microanalysis of Palaeolithic mobiliary art. *Journal of Archaeological Science: Reports* 10: 903–909.

Murillo-Barroso, M., M. Eleazar Costa Caramé, M. Díaz-Guardamino Uribe, L. García Sanjuán and C. Mora Molina 2015. A reappraisal of Iberian Copper Age goldwork: craftmanship, symbolism and art in a non-funerary gold sheet from Valencina de la Concepción. *Cambridge Archaeological Journal* 25(3): 565–596.

Mykhailov, B. 1987. Research of Kamyana Mohyla. *Archaeological discoveries of 1985*, p. 372. Nauka, Moscow [in Russian].

Mykhailov, B. 1992. Sculpture of Vishap head in the Kamyana Mohyla Grotto. *Antiquities of the Ancient Steppe Black Sea region and Crimea* 3: 99–105 [in Ukrainian].

Mykhailov, B. 1993. Stone sculpture from Kamyana Mohyla Grotto in north Azov Sea region. *Archaeology of Ukraine* 1: 110–114 [in Ukrainian].

Mykhailov, B. 2005. *Petroglyphs of Kamyana Mohyla: the semantics, chronology and interpretation*. MAUP, Kiev [in Ukrainian].

Mykhailov, Ya. 2017. The petroglyphs of the Kamyana Mohyla in the context of a shared historical and cultural zone spanning Eurasia. In S. Makhortykh and A. de Capitani (eds), *Archaeology and Paleoecology of the Ukrainian Steppe*, pp. 13–18. FOP Filyuk, Kiev.

Narimanishvili, G., N. Shanshashvili and D. Narimanishvili 2015. New data on menhirs of the southern Georgia. In A. Petrosyan and A. Bobokhyan (eds.), *The Vishap stone stelae*, pp. 176–189. 'Gitutyun' Publishing House, Yerevan.

Nash, G. H. 2005. The aesthetic value of textual images: Pallava script and petroglyphic images on semi-portable stones from Bandung Museum, Indonesia. In J. Clegg and T. Heyd (eds.), *Aesthetics and rock art*, pp. 235–252. Ashgate Press, London.

Neprina, V. 1988. Fishing emergence and development in the territory of Ukraine. *Archaeology of Ukraine* 68: 28–33 [in Ukrainian].

Neprina, V. 1991. Fishing during Mesolithic, Neolithic and Eneolithic of Ukraine. In N. Gurina (ed.), *Fishing during Mesolithic–early Metal Age in the forest and forest-steppe zones of eastern Europe*, pp. 109–115. Naula, Leningrad [in Russian].

Nimura, C. 2015. Prehistoric rock art in Scandinavia: agency and environmental change. In *Swedish Rock Art Series Volume 4*. Oxbow Books, Oxford.

Okladnikov, A. 1975. Miniature sculptures of the Minusinsk steppe. In A. Mandelshtamm (ed.) *Pre-Historic archaeology of Siberia*, pp. 58–63. Nauka, Leningrad [in Russian].

Oshibkina, S., A. Krainov and M. Zimina 1992. *Art of the Stone Age (eastern Europe forest zone)*. Nauka, Moscow [in Russian].

Piotrovskiy, B. 1939. *Vishaps. Stone stelae in the mountains of Armenia.* Armenian Branch of USSR Academy of Sciences, Yerevan [in Russian].

Petrosyan, A. 2009. *Vishap stones*; http://www.iatp.am/vahanyan/vishaps.htm#pr2.

Petrosyan, H. 2015. Some remarks on the vishap-stelae. In A. Petrosyan and A. Bobokhyan (eds.), *The Vishap stone stelae*, pp. 81–98. 'Gitutyun' Publishing House, Yerevan.

Plonka, T. 2003. *The portable art of Mesolithic Europe.* Wydawnictwo Universytetu Wroclawskiego, Wroclaw.

Polkowski, P. 2018. Feet, sandals and the animate landscapes. Some considerations on the rock art of the Dakhleh Oasis, Egypt. In D. Huyge and F. Van Noten (eds,), *What ever happened to the people? Humans and anthropomorphs in the rock art of northern Africa*, pp. 371–395. The Royal Academy for Overseas Sciences and the Royal Museums of Art and History, Brussels.

Porter, S. T., N. Huber, C. Hoyer and H. Floss 2016. Portable and low-cost solutions to the imaging of Palaeolithic art objects: a comparison of photogrammetry and reflectance transformation imaging. *Journal of Archaeological Science: Reports* 10: 859–863.

Radchenko, S. and D. Nykonenko 2019. Western edge of steppe rock art. *Expression* 24: 49–62.

Radovanivic, I. 1996. *The Iron Gates Mesolithic.* MI: International Monographs in Prehistory, Ann Arbor.

Ravdonikas, V. 1938. *Rock art images of Onezhskoe Lake and the White Sea*. Academia nauk, Moskow–Leningrad.

Rudinskiy, M. 1961. *Kamyana Mohyla (complex of rock paintings).* Academy of Sciences of Ukrainian SSR [in Ukrainian].

Sidorov, V. and A. Engovatova 1998. Signs and ornaments on the features from the Zabolotskoe Lake camps. *Russian Archaeology* 1: 126–139 [in Russian].

Schmidt, K. 2006. *Sie bauten die ersten Tempel. Das rätselhafte Heiligtum der Steinzeitjäger*. Verlag C.H. Beck, Munich.

Skoglund, P., C. Nimura and R. Bradley 2017. Interpretations of footprints in the Bronze Age rock art of south Scandinavia. *Proceedings of the Prehistoric Society* 83: 289–303.

Srejović, D. 1972. *Europe's first monumental sculpture: new discoveries at Lepenski Vir.* Thames & Hudson, London.

Studzinskaya, S. 2011. The ancient art of Baikal region (following the small Neolithic figurines materials). *Ancient art in the mirror of archaeology. Honouring the 70th anniversary of D. Savinov*, pp. 36–50. Kuzbassvuzizdat, Kemerovo [in Russian].

Suprunenko, O. 2010. Two monumental sculpture sites of the early Metal Age from the Komsomolsk surrounding. *Museum Herald* 10: 23–30 [in Ukrainian].

Taçon, P. S. C. and C. Chippindale 1998. An archaeology of rock art through informed methods and formal methods. *The Archaeology of Rock Art*, pp. 1–10. Cambridge University Press, Cambridge.

Telegin, D. 1968. *Dnieper-Donets culture.* Naukova dumka, Kiev [in Ukrainian].

Telegin, D. 1971. Eneolithic stellae and the sites of Nyzhniya Mykhailivka type. *Archaeology* 4: 3–17 [in Ukrainian].

Telegin, D. 1991. *Neolithic burials of the Mariupol type (collection of archaeological sources).* Naukova dumka, Kiev [in

Ukrainian].

Telegin, D. 2000. Igren settlement in the Dnieper region and the issue of house construction in the Mesolithic of eastern Europe. *Antiquities of the Ancient Steppe Black Sea Region and Crimea* 8: 3–88 [in Ukrainian].

Telegin, D. and J. P. Mallory 1994. The anthropomorphic stelae of the Ukraine. *Journal of Indo-European Studies Monographs* 11. The Institute for the Study of Man, Washington DC.

Terenozhkin, O. 1960. Kurgans in the Molochnaya river valley. In S. Bibikov (ed.), *Archaeological sites of Ukrainian SSR. Excavations of kurgans near Molochnaya River during 1951*–1952, pp. 3–16. Academy of Sciences if Ukrainian SSR, Kiev [in Ukrainian].

Titova, E. 1982. On interpretation and chronology of the foot compositions from Kamyana Mohyla. In D. Telegin (ed.). *Materials on the chronology of archaeological sites of* Ukraine, pp. 5–15. Naukova dumka, Kiev [in Russian].

Tonceva, G. 1981. Monuments sculpturaux en Bulgarie du nord-est de l'age du bronze. *Studia Praehistorica* 5–6: 129–145.

Tsybrij, V. 2004. Research on early Neolithics camp Razdorskaya 2 in 2003. *Historical and Archaeological Researches in Azov Sea and Lower Don Regions* 20: 34–40.

Tuboltsev, O. 2005. Unpublished materials on the early Neolithic of Nadporozhye. *Antiquities of the Ancient Steppe Black Sea Region and Crimea* 12: 28–49.

Tumanyan, G. 2015. *The cult and practical functions of vishap stones*. In A. Petrosyan and A. Bobokhyan (eds), *The Vishap stone* stelae, pp. 99–120. 'Gitutyun' Publishing House, Yerevan.

Vahanyan, V. and G. Vahanyan 2011. Araratian rock art as a paradigm of communication and visual arts in the past and future. *Papers of XXIV Valcamonica Symposium*, pp. 449–456.

Verner, M. 1973. *Some Nubian petroglyphs*. Univerzita Karlova, Prague.

Živaljević, I. 2012. Big fish hunting: interpretation of stone clubs from Lepenski Vir. In N. Vasić (ed) *Harmony of Nature and Spirituality in Stone. Proceedings of the 2nd International Conference in Kragujevac, Serbia, March 15–16*, 2012, pp. 195–206. Stone Studio Association, Belgrade.

Zhilin, M., S. Savchenko, S. Hansen, K. Heussner and T. Terberger 2018. Early art in the Urals: new research on the wooden sculpture from Shigir. *Antiquity* 92(362): 334–350.

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